

**Before the
UNITED STATES COPYRIGHT OFFICE
LIBRARY OF CONGRESS
Washington, D.C.**

In the Matter of:

**Digital Performance Right In
Sound Recordings and
Ephemeral Recordings**

**Docket No. 2000-9
CARP DTRA 1&2**

REBUTTAL TESTIMONY OF JONATHAN ZITTRAIN

1. As a followup to the direct testimony I provided earlier in this proceeding, I have been asked to expand on my prior testimony in three respects as well as to respond to certain issues raised during the course of the CARP proceeding.

2. In particular, I will discuss factors affecting the future trends of webcast quality, users' options for obtaining permanent digital music files via methods other than "ripping" of streaming audio, and the distinct hurdles of providing streaming audio content over a wireless network.

**FACTORS AFFECTING THE IMPROVEMENT
OF WEBCAST QUALITY OVER TIME**

3. As I previously discussed in written and oral testimony, webcast quality is limited by a number of factors. Arguably most significant among them is the cost of bandwidth – a cost that would increase dramatically were a webcaster to stream signals at higher quality, since higher quality streams require a higher bitrate and thus proportionally more bandwidth.¹ However, even if webcasters were not constrained by

¹ Zittrain direct testimony, ¶¶ 46-47.

the need to minimize bandwidth costs, it would still prove difficult to provide high-quality streaming audio content to most users as a result of the impact of the design of the Internet's infrastructure on streaming transmissions.

The Internet's Backbone Infrastructure

4. The distribution of high-quality streaming audio is hindered in part by certain weaknesses in the Internet's backbone infrastructure. The current design of the Internet relies on so-called "peering points" at which Internet Service Providers (ISPs) exchange data traffic destined from one to another – thereby satisfying the requests of their various users, who often wish to communicate with others who use different ISPs. However, despite continuing improvement and investment, these peering points often suffer from significant congestion, a condition that is likely to persist for the foreseeable future. These weaknesses in the backbone infrastructure are also the Internet's strength, leveraging private networks to seamlessly interlink in order to provide a data path – often multiple ones – from one point of presence to another. But the design was simply not built to emphasize consistent speed of a particular transmission. (The traditional phone network, by contrast, seeks to guarantee a particular bandwidth for the duration of a connection, at the comparatively high cost of maintaining that connection solely for the use of those communicating at that moment.)

5. As I explained in my prior written and oral testimony, the time-sensitive nature of streaming media requires that audio content flows nearly continuously from source to destination. Accordingly, streaming audio content cannot ordinarily be transmitted successfully across peering points (or other portions of the Internet) suffering from network congestion. When such transmissions are attempted, congestion reduces

audio quality from the level otherwise possible at a given bitrate, and congestion can also causes serious disruptions in the transmission. In particular, network congestion may cause breaks, jumps, static, or other artifacts in the ultimate audio signal received by the end user. Thus, network congestion presents serious difficulties to webcasters seeking to improve the quality of their audio signal as ultimately heard by end users.

6. While webcasters can make some adjustments in response to problems with network backbone infrastructure, each such accommodation comes at a cost: Configuring streaming software to guard against extended data delay or loss en route requires increasing “preroll” buffer time (the silence before a stream begins), worsening the user experience by adding additional pauses before music begins and when changing channels. Hiring a premium ISP – one with faster and more reliable connectivity to more points on the Internet – ordinarily costs more than an ordinary ISP, making this a difficult decision in a business where bandwidth costs are already substantial.² Finally, placing streaming audio content “at the edge of the network,” via caching systems like those offered by Akamai, introduces additional complexity into a webcaster’s systems and increases a webcaster’s costs.³ Using a caching system may also limit a webcaster’s flexibility in deploying new technologies or reconfiguring existing systems since corresponding changes would also have to be made to the entirety of the caching system, even as caching units remain deployed to hundreds or thousands of locations around the world. Thus, while providers of streaming media content in principle could attempt to

² Zittrain direct testimony, ¶ 48.

³ For a general description of the design, benefits, and limitations of caching systems, see Zittrain direct testimony, ¶¶ 39-41.

compensate for network problems by making certain adjustments to their systems and infrastructure, in practice their options are limited. As a result, webcasting services will remain sensitive to the quality of network infrastructure; in my experience, network congestion can make webcast quality so poor as to be unpleasant to listen to, and a single failure along the linear path of peers between the webcaster and the ultimate listener is not aided by higher speeds elsewhere – the convoy can only move as fast as the slowest ship.

7. To some extent, it is difficult to distinguish network backbone problems from the “last-mile” network limitations discussed in the section that follows. However, since broadband last-mile connections (such as cablemodem and DSL) in principle provide ample bandwidth for streaming audio, glitches in delivery of streaming audio over broadband connections can be attributed, in general, to network connectivity. My personal experience is that streaming transmissions over even broadband connections – my office connection via a shared T-3, and my home cablemodem – still have the pops, static, and skips that characterize data loss en route. As a result, I feel confident that at least a portion of network problems are properly attributed to backbone congestion, not just to last-mile constraints.

8. To date, improvements in network peering infrastructure have been slow and notably limited. Since many of the contracts governing peering arrangements are confidential, known only to the parties of the contracts, it is difficult to know for certain the causes of delay in that area.

9. The difficulty of improving peering quality may result in part from incentive problems in relations between ISPs. In particular, if one ISP improves its

connection to a peering facility, other ISPs are likely to respond by placing greater weight on that ISP's services as they distribute traffic from that facility, thereby reducing and potentially eliminating any benefit to that ISP's customers of the initial upgrade.⁴ In addition, peering often requires an ISP to work closely with its competitors – a task that may prove difficult due to management structures, the intensity of competition among ISPs, and divergence of their corporate interests.⁵ For example, when network problems arise, scarcity of personnel and expertise may require ISPs to emphasize fixing their own problems rather than assisting with the resolution of problems of their routing peers; here again, market incentives encourage ISPs to focus on themselves, reducing the quality of peering service.⁶ More generally, given the complexity of peering services and the number of entities often present at a single peering point, it is likely to be difficult for ISPs to fully contract on all important axes of peering quality; thus, the structure of peering arrangements provides reason to doubt the quality of the outcome of such arrangements.⁷

10. Furthermore, the structure of the ISP market provides reason to worry about market failure in customers' choice of ISPs. For one, the quality of network services (including the overall speed of data transmissions) is to some extent unverifiable by a potential customer (or a third-party Consumer Reports-type organization) due to the

⁴ "Speed Has Its Price – Backbone Congestion," ISP Planet, <http://www.isp-planet.com/technology/price_of_speed2.html>.

⁵ "Net blackout marks Web's Achilles heel," CNET, <<http://news.cnet.com/news/0-1004-200-6206030.html>>; "How the Big Four ISPs rule the Net Space," I.T., <<http://it.mycareer.com.au/columns/platform/20010122/A15492-2001Jan22.html>>.

⁶ "Net blackout marks Web's Achilles heel," CNET, <<http://news.cnet.com/news/0-1004-200-6206030.html>>.

⁷ "ISPs are class-conscious," CNET, <<http://news.cnet.com/news/0-1004-201-6217928-0.html>>.

logistical difficulty of monitoring network quality, the need for comprehensive measurements covering a representative portion of the Internet over an extended period, and the lack of standardized measurement systems or metrics for doing so. In addition, once an entity becomes a customer of a particular ISP, the entity is to some extent locked in to that ISP; switching to an alternative ISP would entail costs including downtime or increased complexity during transition, reconfiguration of the underlying data lines (likely at extra cost payable to the local telephone company), and reconfiguration or resetting of devices attached to the network (since a new ISP would ordinarily require that all network devices switch to new IP addresses designated by the new ISP).

11. Technical limitations also hinder progress in improving speed and reliability of the Internet backbone. For example, there are significant limitations in the protocol commonly used by network routers to identify and locate other devices on the network and to direct traffic appropriately. These methods, like much of Internet architecture, were designed in anticipation of a far simpler and more limited network design; they struggle to accommodate today's large and complex Internet, and reduced efficiency and quality results. Progress on router protocol improvements remains slow because design enhancements require upgrades to the software (and, in some cases, hardware) of most or all routers connected to the Internet, but no entity has the authority to oversee or require such upgrades.

12. These factors provide significant cause to believe that network backbone architecture will continue to suffer the congestion evident today. As a result, it will likely remain difficult to offer cost-effective high-quality audio streaming from most sources to most destinations for some time to come.

The "Last-Mile" Connection to Residential End Users

13. The so-called "last mile" – local connectivity from end user to ISP – poses an additional bottleneck in the deployment of high-quality streaming audio services.

14. It is widely agreed that high-quality streaming audio requires more bandwidth than is available over dialup modem lines; thus, distribution of high-quality streaming audio requires broadband deployment.⁸ However, to date, rollout of broadband Internet connectivity has been relatively slow. An August 2000 FCC report (the most recent official FCC study available) indicates that approximately one million households and small businesses subscribed to broadband services as of the end of 1999.⁹ Of course, more recent analyses estimate somewhat more customers, but estimates remain on the order of only a few million; the number of subscriber households (as against small businesses and other customers) is even lower.¹⁰

15. The status of broadband network technology shows several reasons why broadband deployment is likely to continue to grow at a relatively slow pace. For one, incomplete deployment of broadband network hardware continues to limit the availability of broadband Internet access to end users. Broadband cablemodem network hardware may be obtained only in geographic locations where cable network operators have upgraded their networks to allow broadband data access, often at costs estimated to be as much as \$700 to \$1,000 per household "passed by" (potentially subscribing to) the

⁸ Zittrain direct testimony, ¶ 50.

⁹ "FCC Report on the Availability of High-Speed and Advanced Telecommunications Services," <http://www.fcc.gov/Bureaus/Common_Carrier/Orders/2000/fcc00290.pdf> ("FCC Availability Report").

¹⁰ "Bandwidth Bandwagon," The Industry Standard, <<http://www.theindustrystandard.com/article/0,1902,15018,00.html>>; "Broadband Availability: Sign Up and Wait," PC World, <<http://www.pcworld.com/resource/printable/article/0,aid,18338,00.asp>>; "Broadband's a Nice Pace if You Can Get It," Washington Post, <<http://www.washtech.com/news/telecom/7902-1.html>>.

service;¹¹ estimates suggest that less than half of Americans can obtain high-speed Internet access via cable lines, while reportedly only 2.5 million Americans subscribe to high-speed cablemodem Internet services.¹² Furthermore, DSL is available only within specified distances from specially-equipped telephone company facilities; with current technology, DSL cannot be made available to the 20% of households beyond these distances (which vary according to the specific configuration of a DSL installation) from a facility so equipped¹³ or to those near facilities without the necessary equipment. These factors have limited DSL's residential success to date, and reportedly only 1.5 million Americans actually have high-speed DSL Internet access.¹⁴ Importantly, it is likely that large portions of the populations unserved by one technology are also unserved by the other, since both technologies traditionally focus on the most-profitable customer areas of relatively wealthy urban areas.¹⁵ While other broadband implementation methods are in principle possible, using connection methods as diverse as satellites and power lines, to date their deployment has been minimal.¹⁶ Thus, the limited deployment of cablemodem and DSL broadband network hardware prevents many Americans from obtaining

¹¹ "Hybrid Fiber-Coax Technology Overview,"

<<http://www.analog.com/publications/whitepapers/misc/hfc.html>>; "Bringing Home the Bandwidth: HFC," <http://www.harmonicinc.com/sol_BringingHomeBandwidth.html>.

¹² Various estimates, including: "Bandwidth Bandwagon," The Industry Standard, <<http://www.thestandard.com/article/0,1902,15018,00.html>>; "Broadband Availability: Sign Up and Wait," PC World, <<http://www.pcworld.com/resource/printable/article/0,aid,18338,00.asp>>; "Broadband's a Nice Pace if You Can Get It," Washington Post, <<http://www.washtech.com/news/telecom/7902-1.html>>; FCC Availability Report.

¹³ FCC Availability Report.

¹⁴ "Broadband's a Nice Pace if You Can Get It," Washington Post, <<http://www.washtech.com/news/telecom/7902-1.html>>.

¹⁵ FCC Availability Report; "Advanced Telecommunications in Rural America," <http://www.its.bldrdoc.gov/tpr/2000/its_t/adv_tele/adv_tele.html>.

¹⁶ FCC Availability Report.

broadband Internet access, and indeed it is estimated that narrowband will remain dominant through at least 2005.¹⁷

16. The structure of the market for broadband Internet access also limits the deployment of broadband service. Broadband is ordinarily provided by local monopolies, namely the few telephone and cable companies that have existing wired connections to households in a geographic area. Indeed, while some households may be able to choose from two providers of underlying broadband services (namely DSL and cablemodem, though perhaps resold via any of several firms that repackage the use of the same underlying connection mechanism), it is rare that more than two distinct mainstream broadband-capable connection mechanisms would be available to a single household.¹⁸ At my house in Cambridge, Massachusetts, for example, my options for high-speed data connectivity are via DSL from phone company Verizon and via cablemodem from cable provider AT&T. In my neighborhood, then, competition takes place, at best, among these two technologies, with a corresponding lack of intensity of competition relative to a market with more competitors. Furthermore, the relations between telephone companies and competitive providers of DSL often complicate the installation, troubleshooting, and maintenance of DSL, thereby slowing rollouts, increasing costs, and reducing reliability of that technology.¹⁹

¹⁷ "Broadband Today," Cable Services Bureau, FCC, <<http://www.fcc.gov/Bureaus/Cable/Reports/broadbandtoday.pdf>> (hereinafter "Broadband Today").

¹⁸ FCC Availability Report.

¹⁹ "Verizon sues Covad as DSL battle turns nasty," ITWorld, <<http://www.itworld.com/Net/2574/VerizonsuesCovadasDS406/>>; "Lawsuit looks for \$1 billion from Verizon," IDG, <<http://www.nwfusion.com/news/2001/0216verizsuit.html>>.

17. Regulatory challenges further hinder the market for broadband Internet access. The regulated nature of local telecommunications – requiring approval for the installation of new wiring, for example – imposes restrictions on competition via additional costs, complexity, and delays; thus, whatever the benefits of this regulation, it reduces the speed of deployment of broadband connectivity. In addition, prospective operators of local broadband networks fear the possible requirement of opening usage of those networks to their competitors, as has been required of cablemodem networks in some jurisdictions, thereby reducing the expected return to a network operator's substantial up-front investment and reducing the appeal of subsequent expansion of service.²⁰

18. Furthermore, most broadband deployments require so-called “truck rolls” – visits from a technician, or in some cases multiple technicians, to install, reroute, or reconfigure physical wiring as well as to attach broadband access devices to a user's computer and to reconfigure a user's computer as necessary.²¹ However intense a broadband provider's desire to increase its customer base, each technician can ordinarily visit only a few homes per day. Thus, deployment of broadband access is limited by technician availability, and customers often wait weeks or even months for a broadband installation.²² Of course, technician visits entail other limitations also: For the service

²⁰ FCC Availability Report.

²¹ So-called “self-install kits,” which can in some cases eliminate the need for a technician visit, often entail other compromises. For example, DSL self-install kits may require the installation of additional hardware, sometimes at extra cost, associated with every telephone device in the entirety of a user's household. Where available, cablemodem self-install kits require that the appropriate cable be available in the vicinity of a user's computer. Self-install kits may prove difficult and intimidating to novices, and it is my understanding that users' success rates with such kits are lower than with most other computer peripherals.

²² “Broadband Availability: Sign Up and Wait,” PC World, <<http://www.pcworld.com/resource/printable/article/0,aid,18338,00.asp>>.

provider, technicians yield high costs for wages, training, and equipment. For end users, technician visits can cause significant scheduling difficulties, especially because end users in many cases must take one or several days off from work in order to accommodate the uncertain schedules of service installers.

19. Economic weakness further reduces the speed of deployment of broadband Internet access. From the perspective of service providers, economic weakness reduces the availability of capital, preventing expansion into new markets, and also prevents new entrants from beginning to supply broadband access. In addition, a lack of capital weakens existing firms; for example, leading DSL providers Covad and Northpoint have both filed for bankruptcy, crippling their ability to recruit new customers as well as to serve existing customers.²³ From the perspective of end users, the additional cost of broadband, above and beyond ordinarily dial-up Internet access, may prove a stumbling block in the face of reductions in consumer spending.²⁴

20. As word spreads of consumer dissatisfaction with broadband services, signups of new customers will likely be affected. Multiple lawsuits currently allege delays, poor service speed, and inadequate customer service.²⁵ Whether or not these lawsuits reflect actual shortcomings in broadband services, the perceived divergence

²³ "NorthPoint's Bankruptcy Burns Customers," The Industry Standard, <<http://www.thestandard.com/article/0,1902,23232,00.html>>; "Last-mile options dwindle," InfoWorld, Aug. 20, 2001.

²⁴ "Costs, fall of Napster make fast Internet access expendable for many," San Jose Mercury News, Aug. 28, 2001.

²⁵ "DSL Lawsuits Multiply in California," PC World, <<http://www.pcworld.com/resource/printable/article/0,aid,43202,00.asp>>; "Southwestern Bell DSL customers sue over bandwidth," CNET, <<http://news.cnet.com/news/0-1004-200-2549826.html?tag=rltdnws>>.

between advertising and reality may reduce consumer demand for broadband access, thereby slowing deployment of broadband services.

21. Finally, as broadband Internet rollouts continue to proceed more slowly than repeatedly predicted, current predictions of rapid rollouts should be evaluated with significant skepticism. Multiple news articles and other analyses reflect that the deployment of high-speed residential Internet access progress has not met prior analyst and press expectations²⁶ and has consistently surprised even so-called "experts."²⁷ This unpredictability is consistent with my own personal experience. Going forward, predictions likely remain equally unreliable; indeed, even within this document, I have cited statistics that differ, widely in some instances, in their specific quantifications of service deployment and availability.

22. On balance, I hesitate to make predictions except to predict that the future is unpredictable. But review of progress to date and analysis of market structure provides significant reason to believe that end users' connections to the Internet will not increase as rapidly in speed as some have predicted. Of course, given the dependence of high-quality streaming audio on broadband Internet access, these delays in turn restrict the availability and use of high-quality streaming audio services.

²⁶ "Broadband Data Services in the Local Loop DSL Dementia vs. Cable Modem Madness," Tech Online Review, <<http://www.techonline.com/TOL/newsletter/rev6/HypeDementia.html>> ("The slow rollout of cable modem services (vs. what was predicted in 1996) and the very slow rollout of DSL services").

²⁷ "Broadband Today," Cable Services Bureau, FCC ("[W]e have learned that there is yet much to learn. ... We have learned that not even the experts are any more 'sighted' at this early stage of the rapidly evolving broadband industry than the wise men of Indostan ... The splintered and divergent views expressed by the experts in our Monitoring Sessions demonstrate the difficulty in arriving at these conclusions.").

USER PREFERENCE FOR OBTAINING PERMANENT
DIGITAL MUSIC FILES VIA METHODS OTHER
THAN "RIPPING" OF STREAMING AUDIO

23. It has been suggested that consumers may come to employ third-party "ripping" programs as a means of capturing streaming audio content to their hard drives for subsequent playback on demand. As yet, news reports and online discussions indicate that the use and awareness of such programs is extremely limited, restricted to a small subset of enthusiasts and technical experts.²⁸ As discussed below, this is hardly surprising, and there are significant reasons to doubt that such methods will increase significantly in their rate of use.

**The Quality of Streaming Audio Compared
to Other Digital Audio Formats**

24. The low quality of streaming audio, especially relative to digital music available by other methods, encourages most Internet users to obtain digital music files from sources other than streaming media, as does the lack of flexibility in streaming audio transmission methods.

25. Indeed, the continued availability of so-called "Napster clone" file-sharing services means that users continue to have relatively easy access to downloadable digital audio content that is, from their perspective, "free." Such services include AudioGalaxy, BearShare, FastTrack, gnutella, iMesh, KaZaA, and Morpheus, which jointly reportedly have more users than Napster did at its peak.²⁹ While sound quality varies among files within these services, bitrates are ordinarily on the order of 128kbps, more than twice the

²⁸ This reflects my personal review of download counts in CNET download.com, of Google and Deja search results, and of Lexis articles, in each case using as search keywords the names of circumvention tools discussed previously in this proceeding.

²⁹ "Music downloads soar," CNET, Sept. 6, 2001, <<http://news.cnet.com/news/0-1005-200-7080479.html>>.

bitrate available from most streaming services and more than six times the bitrate of many, making the sound quality of these file-sharing services noticeably better than that of streaming audio. Supplemental Exhibit 1, attached to my testimony, details the bitrates of a variety of streaming audio services.

26. Furthermore, since Napster-like services offer files for permanent storage on a user's computer, the services allow song playback on demand, without the restrictions imposed by the eligibility requirements for the statutory performance license that is the subject of this CARP and without the other limitations imposed by current streaming implementations. Users value this flexibility because it allows the enjoyment of audio content in ways impossible with streaming audio services: When users retrieve digital music files from Napster-like services, they can listen to specific songs in an arbitrary order of their choosing; they can "burn" their own CDs; and they can listen to the music of their choice at arbitrary locations away from their computers thanks to a wide variety portable audio players supporting standard digital music formats. Of course, streaming audio services ordinarily provide none of these additional features.

The Use of "Stream-Ripping" Tools

27. The difficulty of obtaining, installing, and using "stream-ripping" tools also discourages users from obtaining digital music files in this way.

28. In my experience, stream-ripping tools are often distributed from sites with counterintuitive interfaces, frequently-changing addresses, and unreliable connectivity. As a result, stream-ripping tools are hard to find and download, especially for novices. Furthermore, the installation packages and subsequent user interfaces of these tools are generally less intuitive and less "polished" than the commercial software

most users ordinarily rely on. These weaknesses reflect both the programs' origins as "hacker tools" and the difficulty of their task, often connecting to a player or other program in a way the author of that program did not anticipate or intend to allow. Moreover, it is difficult to "rip" one's song or songs of choice once installed, since streams are often initiated mid-performance, resulting in an incomplete ripped copy of the song. For these reasons, stream-ripping tools would be unappealing to most users even if there were no obvious alternative. However, with numerous Napster-like systems simultaneously providing more intuitive and attractive user interfaces to a more straightforward content retrieval system, stream-ripping tools are especially undesirable.

29. In short, then, users who seek high-quality permanent copies of digital music ordinarily avoid stream-ripping methods due to their difficult installation and use, their low quality, and the availability of high-quality easy-to-use substitutes. Given the continued availability of multiple services providing high-quality digital music files for download and playback and demand, and given the technical difficulties involved in streamripping, there is little basis for predicting that streamripping will rise in popularity in the foreseeable future.

FACTORS AFFECTING THE STREAMING OF AUDIO CONTENT OVER A WIRELESS NETWORK

30. It has been suggested that consumers may come to receive streaming audio signals from webcasters via a variety of handheld terrestrial wireless devices.³⁰ While many firms have stated their intentions to offer or facilitate such services, I could not find a single article documenting any such system actually in operation in the United

³⁰ I mean to focus this discussion on handheld devices receiving unicast data from local antennas, using so-called "3G" and related telecommunications systems, rather than receiving broadcast data from satellites.

States at this time, and of course neither is there evidence of such systems in operation in the past. There is strong reason to believe that wireless access to streaming audio content will not be employed by ordinary users within the foreseeable future.

Adoption Rates of High-Speed Wireless Networks

31. The slow development of wireless streaming audio reflects that high-speed wireless access mechanisms continue to grow more slowly than previously predicted.

32. Delays in the deployment of high-speed wireless networking result from a variety of factors: Significant technical difficulties remain as services attempt to balance competing requirements of handset size, handset battery life, speed, reliability (especially in the face of transmission interference), network hardware cost, and density of cells (since decreasing cell size requires the purchase of additional hardware as well as the acquisition of rights to additional antenna installation points).³¹ Furthermore, regulatory uncertainty leaves business models in question, while other regulatory delays slow progress generally. Significant logistical difficulties also hinder deployment, as wireless providers must upgrade network hardware deployed in thousands of distinct network cells in order to achieve coverage of even a few major metropolitan areas. In addition, economic weakness prevents interested firms from obtaining the capital necessary to install equipment, and economic weakness also brings into question the willingness of users to pay for wireless access.³² Indeed, waning expectations for short-run high-speed

³¹ "3G Wireless speeds fail to match claims," Computerworld, <http://www.computerworld.com/cwi/story/0,1199,NAV47_STO59392,00.html>; "AT&T Wireless launches 2.5G with limitations," CNN, <<http://www2.cnn.com/2001/TECH/ptech/07/20/ATT.wireless.idg/index.html>>.

³² "Cash crunch for wireless players?" CNET, <<http://news.cnet.com/news/0-1004-200-4495717.html>>; "3G 'Squeezed' By Other Wireless Systems - Merrill Lynch," Washintonpost.com, <<http://www.newsbytes.com/news/01/165960.html>>.

wireless network deployments reportedly even reduce attendance at conferences of prospective wireless network providers, preventing inter-firm coordination on technical standards and providing further reason to doubt the short-term interoperability and coverage of such systems.³³

33. Deployment of high-speed wireless networks relies critically on the availability of spectrum for this purpose. In the United States, it is widely thought that the military provides the most likely source of sufficient spectrum, for most other spectrum has already been allocated, while private-sector space is already intensively used by a variety of entities for other purposes.³⁴ However, the military has so far been slow to release spectrum, citing a variety of legacy communications systems dependent on the use of particular frequencies. In light of recent threats to national security, news reports indicate that the military is especially unlikely to release its allocations for use by the public, further delaying deployment of high-speed wireless services.³⁵ Other entities currently using spectrum space have also refused to offer that space for high-speed wireless data transmissions, and the FCC has specifically decided not to order them to do so.³⁶

34. Finally, there remains no well-defined standard for high-speed wireless networks. Rather, competing manufacturers continue to advocate multiple incompatible

³³ "Wireless Web Isn't Connecting," Wired News, <<http://www.wired.com/news/print/0,1294,47077,00.html>>.

³⁴ "Military puts squeeze on wireless industry," CNET, Dec. 1, 2000, <<http://news.cnet.com/news/0-1004-200-3953202.html>>.

³⁵ "Spectrum off-limits after attack," MSNBC.com, Sept. 19, 2001, <<http://www.msnbc.com/news/631254.asp>>.

³⁶ "Ruling Sets Back 3G Airwaves Plan," Los Angeles Times, <<http://www.latimes.com/business/la-000076664sep25.story>>.

systems, increasing costs both for providers and end users, causing uncertainty and further slowing system deployment.³⁷

35. For all these reasons, the development of high-speed wireless access has been slower than previously predicted.

Users' Experience of Accessing Streaming Audio Content Via Wireless Networks

36. The distribution of streaming media content via wireless network devices also causes certain additional concerns from the perspective of end users.

37. Likely wireless network pricing models hinder the deployment of streaming audio over wireless networks. In existing wireless implementations, users are ordinarily charged per minute connected or per byte of content received; few wireless communication services offer unlimited network usage. In this context, streaming media fares especially poorly, for streaming connections are both long in duration and substantial in their demands for network bandwidth. While it is possible that network providers may offer a discount on wireless bandwidth when used to stream audio files, this seems an unlikely strategy when wireless networks in major metropolitan areas ordinarily face high capacity utilization rates even without the burden of transmitting streaming audio; indeed, providers planning high-speed wireless services suggest that they will charge a premium for high-speed access, not offer a discount.³⁸ However, if access to wireless streaming audio content bears a significant cost to end users, there is

³⁷ "Wireless Web Isn't Connecting," Wired News, <<http://www.wired.com/news/print/0,1294,47077,00.html>>.

³⁸ "High-speed mobile wireless takes three giant steps," Computerworld, <http://www.computerworld.com/cwi/story/0,1199,NAV47_STO58848,00.html>.

reason to expect users to go elsewhere for music content; users could listen to ordinary FM transmissions, or could load digital music files into any of a variety of portable digital music players.³⁹

38. Users will also likely be disappointed to find that early wireless streaming audio services fail to live up to existing standards for reliability, sound quality, and battery life. As is the case for webcast transmissions over ordinary wired networks, successful playback of streaming audio will likely require a continuous flow of data from source to user – a difficult feat when wireless connection quality often fades in and out within a small geographic area, or even within a building. Furthermore, with wireless bandwidth at a premium for the foreseeable future, wireless streaming audio systems are likely to use the lowest possible bitrate, worsening the user experience relative to FM radio and portable digital music players. Finally, experience with portable consumer electronics demonstrates that users highly value device battery life; however, current cellular phones ordinarily allow at most several hours of connection per charge, a factor that is likely to hinder consumer appeal of such devices when used to receive streaming audio.

39. In short, then, in the foreseeable future, wireless communications systems have not been and likely will not be used by ordinary users for the purpose of receiving streaming audio content.

³⁹ “Wireless digital music slow in coming,” CNN,
<<http://www2.cnn.com/2001/TECH/ptech/07/23/future.digital.music.idg/index.html>>.

I hereby declare under penalty of perjury under the laws of the United States that the foregoing testimony is true and correct to the best of my knowledge, information and belief.



Jonathan L. Zittrain

Executed this 2nd day of October, 2001.